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INFORMATION FLOW
IN R&D LABORATORIES

by

Thomas J. Allen * and Stephen I. Cohen +

May, 1968

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ABSTRACT

Social relations and work group structure are examined to determine their relative influence upon the structure of the technical communication network in two research and development organizations. The structure of this network is found to result from the interaction of both of these sets of relations.

A second hypothesis concerns the communication habits of the sociometric "stars" in the technical communication network. They are found to either make greater use of individuals outside the organization when they need information, or to read the literature more than do the remainder of the laboratory population.

INFORMATION FLOW IN R&D LABORATORIES

Several recent studies¹ of industrial and government scientists and engineers have shown an inverse relation between extra-organizational communication and performance, contrasting with a direct relation between intro-organizational communication and performance. In a study of academic scientists, however, Hagstrom² found a strong positive relation between performance and extra-organizational communication. In this instance, the organization (an academic department) occupies a subsidiary position to a more inclusive social system: the "invisible college" or academic discipline. While the communication process is external to the academic department it is internal to the academic discipline. It is not, of course, the external communication, per se, which degrades performance, but other factors such as lack of necessary knowledge on the part of the engineer or scientist seeking information. The internal channels are better able to compensate for this basic deficiency than are external ones.

¹ C.W. Shilling and J. Bernard, Informal Communication among Bioscientists. (Washington: George Washington Univ. Biological Sciences Communication Project). Report No. 16A-1964;

T.J. Allen, The Use of Information Channels in R&D Proposal Preparation. (Cambridge: MIT Sloan School of Management). Working Paper No. 97-64, 1964;

T.J. Allen, Sources of ideas in parallel R&D projects. In Yovits, M.C., et. al. (Ed.). Research Program Effectiveness. (New York: Gordon and Breach, 1966b);

T.J. Allen, Performance of communication channels in the transfer of technology. Industrial Management Review, 8, 1966c, 87-98.

² W.O. Hagstrom, The Scientific Community (New York: Basic Books, 1965).

The concept of a shared coding scheme³ produces a rather simple and straightforward explanation. In industrial and governmental situations, the laboratory organization assumes an overwhelming importance to its members. In these contexts, the organization demands a degree of loyalty and affiliation far outweighing that required by academic departments. In addition, the members of such organizations acquire through common experience and organizational imposition shared coding schemes, or common ways of ordering the world, that can be quite different from the schemes held by other members of their particular discipline. This is not true of the academic scientists. They generally feel more aligned with scientists who share their peculiar research interests than with a particular university or department. Their coding scheme would therefore be more aligned with that of other scientists, who share their particular research interests regardless of organizational affiliation. The "invisible college" now becomes the mediator of the coding scheme.

The existence of different coding schemes in different organizations introduces the possibility of a mismatch and resulting difficulties in communication between members of the organizations. Allen⁴ has proposed this explanation for the observed inverse relation between extra-organizational communication and performance. The mismatch problem is compounded when, as is often the case, incompatibilities between the two coding schemes go unrecognized, or when identical coding systems which do not in fact exist are assumed.

There are, of course, possible measures that can reduce this organizational

³D. Katz and R. Kahn, A Social Psychology of Organizations. (New York: McGraw Hill, 1966), Chapter

⁴T.J. Allen, op. cit., 1966c, p.

boundary impedance. One that may well take place under uncontrolled circumstances is a two-step process, in which certain key individuals act as bridges linking the organization members to the outside world. Information then enters the organization through these individuals, who are capable of operating within and transmitting between two coding schemes.

The possibility that such individuals exist, who in effect straddle the coding systems and are able to both function efficiently in the two, and perform a transformation between them, holds promise for their potential utilization in information transfer. The present study examines the flow of information both into and within the confines of a small research organization. But before turning directly to the problem at hand, let us briefly review a body of research on the flow of information in a somewhat different context.

Public Opinion Research

Twenty years ago, Lazarsfeld, Berelson and Gaudet,⁵ to explain a phenomenon which they had observed in a study of popular decision-making during the course of the 1940 election campaign, first proposed what has become known as the two-step information flow hypothesis. It appeared that ideas flow from radio to print to opinion leaders and from them to the remainder of the population. Katz and Lazarsfeld⁶ in a subsequent study built a major hypothesis around this "two-step" process and were able to marshall considerable support for it. Instead of a simple direct connection between mass media and the general public they discovered the process to be more complex and to involve a

⁵P.F. Lazarsfeld, B. Berelson and H. Gaudet, The People's Choice (New York: Duell, Sloan and Pierce, 1948).

⁶E. Katz and P.F. Lazarsfeld, Personal Influence (New York: Free Press, 1955).

number of intervening variables. Furthermore, the intervening variables (e.g., relative exposure, channel preference, the effect of message content, attitudes and psychological predispositions of the audience) all involve the individual's social attachments to other people, and the character of the opinions and activities which he shares with them. Thus, the response of an individual to a communicated message could not be accounted for without reference to his social environment and to the character of his interpersonal relations. This two-step flow was found to be mediated by "opinion leaders" who in every stratum of society perform a relay function: controlling the flow, for example, of political information from mass media to electorate, and thus influencing the vote. It was found that the opinion leaders were considerably more exposed than the rest of the population to the formal media of communication. As a result, Lazarsfeld and his colleagues⁷ argued that "ideas flow from radio and print to opinion leaders and from these to the less active sections of the population."

Specifically, it was found that "leaders in a given sphere (fashions, public affairs, etc.) were more likely to be exposed to the media appropriate to that sphere."⁸ In addition to mass media exposure, influentials tend to have a greater number of interpersonal contacts outside of their own groups. Thus in a study of drug adoption by physicians, Coleman, Katz and Menzel⁹ discovered that the more influential doctors were characterized not only by greater attention to medical journals but also by more frequent attendance at out-of-town

⁷P.F. Lazarsfeld, et. al. op. cit.

⁸E. Katz, The two-step flow of communication. In Schramm, W. (Ed.) Mass Communications (2nd ed.; Urbana: University of Illinois Press, 1960).

⁹J.S. Coleman, E. Katz and H. Menzel, Medical Innovation: A Diffusion Process (New York: Bobbs Merrill, 1966).

meetings and the diversity of places with which they maintained contact. Similarly in studies of the adoption of such innovations as hybrid seed corn, Rogers (1962) concluded that opinion leaders, in this instance, can be characterized in terms of the relative frequency of their trips out of town, and in a general predisposition toward "cosmopolitanism."

Relation to the Flow of Technology

The most obvious connection between the flow of scientific and technological information and the studies cited above would appear to be through the studies of the adoption of agricultural and other innovations. The qualitative nature of the information being exchanged is certainly more akin to the type of information with which we are concerned, than is, for example, the information contained in communications which influence a person's vote or his choice of food or fashions. The results of such studies have been summarized in the volume by Rogers.¹⁰ There is certainly a clear analogy between transfer of information in the form of innovations from technology into societal utilization, and our present concern, the transfer of information from one organization to another within science or technology. The research to be reported in the paper has, therefore, drawn heavily upon the work of both the mass communication theorists and of social scientists concerned with the transfer of innovation.

Katz and Lazarsfeld¹¹ and Rogers¹² stress the importance of the individual's face-to-face relations in transferring information of these two diverse

¹⁰E.M. Rogers, Diffusion of Innovations (New York: Free Press, 1962).

¹¹E. Katz and P.F. Lazarsfeld, op. cit.

¹²E.M. Rogers, op. cit.

types. Katz and Lazarsfeld, for example, confess that their studies have led them to "rediscover" the primary group. There is quite clearly a parallel in the research and development laboratory. Strong evidence has been found that engineers do not make very great use of the formal communication media, and that they rely much more heavily upon oral channels. There is also some evidence from the studies by Allen¹³ that other members of the engineer's immediate work group or colleagues and friends in other parts of the organization are often instrumental in delivering information to him, or making him aware of the existence of a particular source. Repeatedly, when the researchers attempted to determine the source of a particular idea, it turned out that no single source, but rather several sources had contributed to the discovery or formulation of the idea. In one case, an engineer's colleague hears a paper delivered at a conference of the Society of Automotive Engineers, associates the device described with a problem which the engineer has and tells him about it. The engineer, himself, follows up the lead, searches the literature, contacts the man who delivered the paper, and gets in touch with a vendor who can supply some of the hardware. Another case is quite similar. A vendor visits a particular engineer, and tells him about a new piece of equipment which his company has developed. The engineer knows of a colleague to whose problem this equipment might be relevant. He suggests that vendor contact his friend; the vendor does, and the application is found appropriate.

These instances are stated exactly as they were related to the interviewer, and they are not isolated occurrences. Very frequently a mediator either directly relates information which he has obtained from another source, or

¹³T.J. Allen, op. cit., 1966c.

indirectly assists in the transaction. There is sufficient evidence from these studies to indicate the possibility of a two-step flow in technological communication.

The Hypotheses

Two major hypotheses have been generated based upon the findings of earlier studies in mass communication and upon other research on information flow.

1. The influence of the primary groups. The structure of the laboratory's technical communication network will be significantly influenced by two factors:
 - a. The structure of the formal organization. That is, the pattern of formal organizational relationships that exists in the laboratory.
 - b. The structure of the informal organization. That is, the pattern of friendships and social relations that exists among members of the laboratory.
2. Technological gatekeepers. There can exist in an R&D laboratory certain key individuals who are capable of effectively bridging the organizational boundary impedance and who provide the most effective entry point for ideas into the lab. These gatekeepers will be characterized in three ways:
 - a. They will be the people to whom others in the lab most frequently turn for technical advice and consultation.
 - b. They, themselves will be better exposed (than others in the lab) to such formal media as the scientific and technological literature.
 - c. In addition to exposure to formal media, the gatekeepers will maintain a greater degree of informal contact with members of the scientific/technological community outside of their own laboratory.

RESEARCH METHODS

As an initial step in testing the hypotheses, a sociometric study of interpersonal relations and information flow was conducted in two R&D organizations.

The first of the two organizations is a 48 man department¹⁴ of a medium size (approximately 5,000 employees) aerospace firm. Since the entire laboratory could not be studied in this instance, hypothesis 2 could not be tested. The boundary of the organization being studied lay within the confines of a larger laboratory, no attempt was made initially to test the gatekeeper hypothesis. A subsequent attempt to accomplish this through a more inclusive study of the organization was aborted due to poor cooperation.

The second laboratory is relatively small and self-contained, and is actively engaged in work on new materials and devices in the fields of direct energy conversion and solid state electronics, for both military and industrial applications. The data were collected from 23 of the 34 professional members of the laboratory by means of written questionnaires followed up by brief personal interviews.¹⁵

Sociometric Relations

Table I shows a listing of some of the different sociometric responses that were obtained. The questions were aimed at determining the manner in which

Insert Table I here

¹⁴Thirty of the 48 members of this department actually returned questionnaires. This is an extremely poor response for a sociometric study, and the data would not be reported were it not for the fact that they add a rather interesting supplement to the findings in the second organization.

¹⁵Examination of resumes for the six non-respondents reveals no striking differences from the other lab members. One of the six holds a Ph.D. and two had been just recently hired by the laboratory. The two recent hires explained that they were not well enough acquainted with other members to complete the questionnaire in a meaningful manner. Of the remaining four non-respondents, one was out of town at the time, and the other three simply had an aversion to questionnaires.

Table 1. Sociometric Relations Studied

socialization	name the 3 or 4 people from the lab with whom you meet most frequently on social occasions
work group	name the people whom you consider to be members of your present work group
technical discussion	name the 3 or 4 people with whom you most frequently discuss technical matters
critical incident information	think back to your most recently completed research project -- the source, if any, from which the respondent reported having received special information that influenced him during the course of his last completed research project
research idea	to whom in the lab would you first express an idea for a new research project

information flow in the lab relates to other sociometric choices. For instance, are the people that a respondent sees socially the same people with whom he has technical discussions? Two distinct classes of sociometric relations were considered. The first of these deals with the social relations within the lab, and the second provides an indication of the routing of technical information through the organization. To the sociometric queries in laboratory B were added a third class of question. These questions deal with individual information gathering behavior, and include questions on technical reading habits, and degree of technical discussion and contact with members of other organizations (Table II).

Insert Table II here

The Sociograms

Figures 1 and 3 illustrate the pattern of two sets of relationships among the members of laboratory B. In Figure 1, the arrows indicate the direction of

Insert Figure 1 here

social contact choices; Figure 3 shows the pattern of technical discussion choices. The large circle labelled "non-Ph.D." in Figure 1(b) represents the Ph.D. to non-Ph.D. choices, and shows very few social contacts in this direction. The circle labelled "all Ph.D.'s combined" in Figure 1(a) gives an indication of which non-Ph.D.'s choose into the Ph.D. group. Nine non-Ph.D.'s do so, but in only two cases, subjects 24 and 28, is the choice reciprocated. Reciprocal choices are indicated in the diagram by double-headed arrows.

Table 2. Factors Related to Information Gathering Behavior

1. the number of technical periodicals read regularly by each subject.
 2. the extent to which each subject reports using the following information sources.
 - a. personal friends outside the organization
 - b. technical specialists within the lab
-

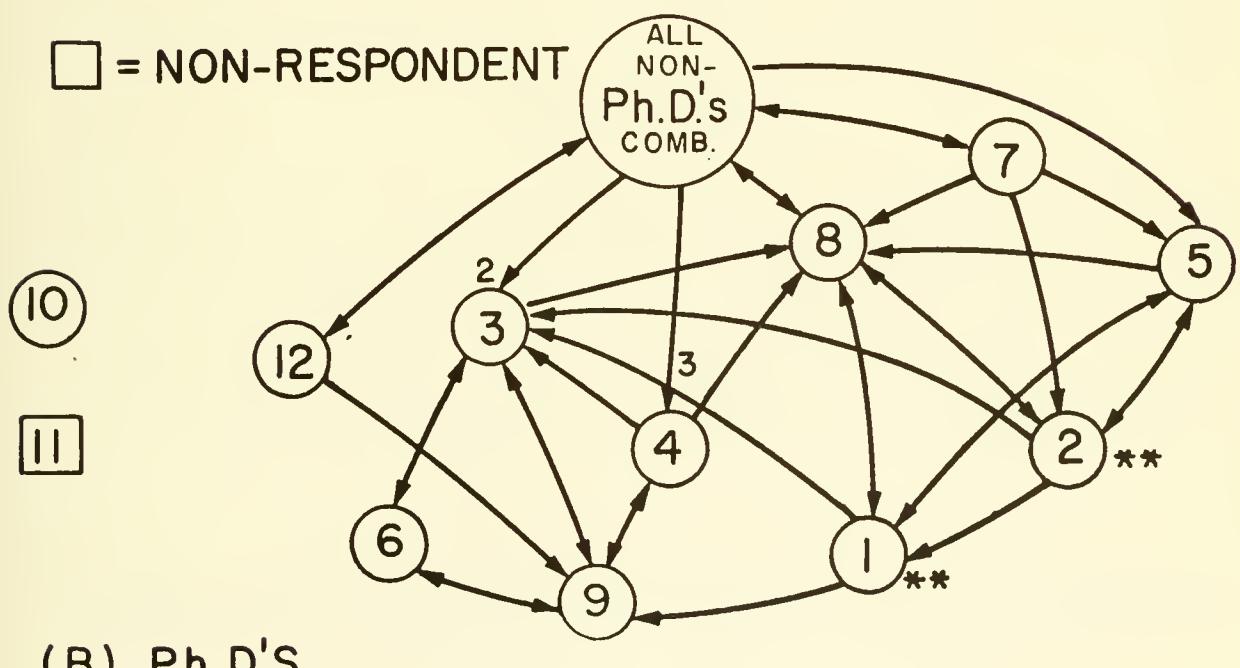
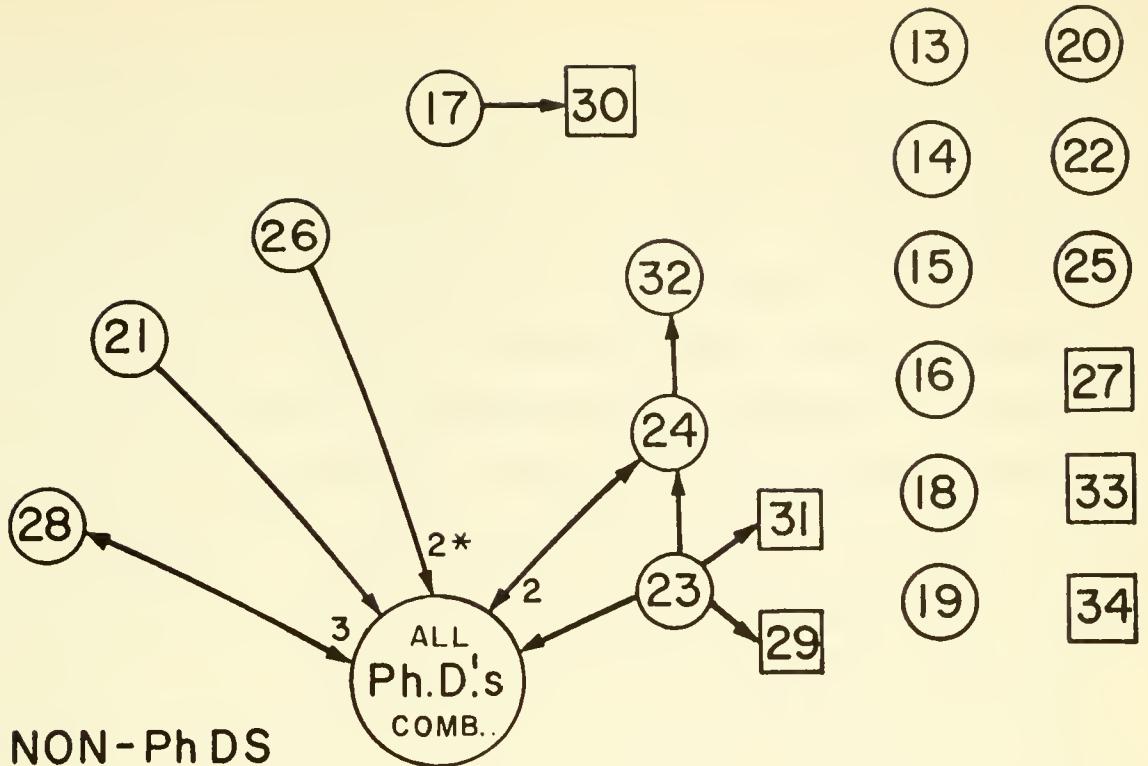


FIGURE I. SOCIAL CONTACT - CHOICES

* WHERE MORE THAN ONE CONNECTION EXISTS, A NUMBER NEXT TO THE ARROWHEAD INDICATES THE NUMBER OF CONNECTIONS.

** NUMBERS 1 AND 2 ARE THE RESEARCH DIRECTORS OF LABORATORY B.

Sociograms are compared for two or more types of choice (e.g., technical discussion and socialization), by comparing the degree of overlap between two actual networks with the amount of overlap which would be expected under chance conditions. Since the number of overlapping choices expected by chance will vary as a function of the number of sociometric choices made by each individual,¹⁶ an expected number of overlaps is computed for each person who returned a questionnaire. This expected number is based on a binomial probability model in which the probabilities of overlap and non-overlap are a function of the number of actual choices made by each individual respondent.¹⁷ An example of the number of overlaps which are expected at random for a respondent choosing three other persons for socialization and four for technical discussion is shown in Table III. Expected values for the total sample are obtained by summing all of

Insert Table III here

the individual values. The observed distribution of overlaps is then compared with this expected distribution by means of a one-sample Kolmogorov-Smirnov Test.

In Figure 2 and Figures 4 through 6, the bar graphs compare the number of overlapping sociometric choices which were observed with the number predicted by

¹⁶ For example, if every individual in the laboratory chose five others for socialization and five for technical discussion, there would be expected, by chance, a greater number of common connections in the two networks than would be expected if each person had chosen only four others.

¹⁷ The problem is directly analogous to the classical "birthday problem" (W. Feller, An Introduction to Probability Theory and Its Applications, New York: Wiley, 1950, pp. 31-32), except that each individual is allowed to have several "birthdays" (e.g., four), and the number of days in the year is set equal to the size (34) of the organization from which choices are made.

Table 3. Probabilities of Overlap Among Choices
for a Respondent Choosing Four Persons
in One Sociometric Network and Five in
Another

number of choices common to both relations	0	1	2	3	4
probability of occurrence	0.02	0.24	0.48	0.24	0.02

the random model described in the preceding paragraph.

RESULTS AND DISCUSSION

Relation Among Sociometric Choices

Figure 2 presents results of the comparison of three communication-oriented sociometric choices with the socialization choice. There is strong agreement

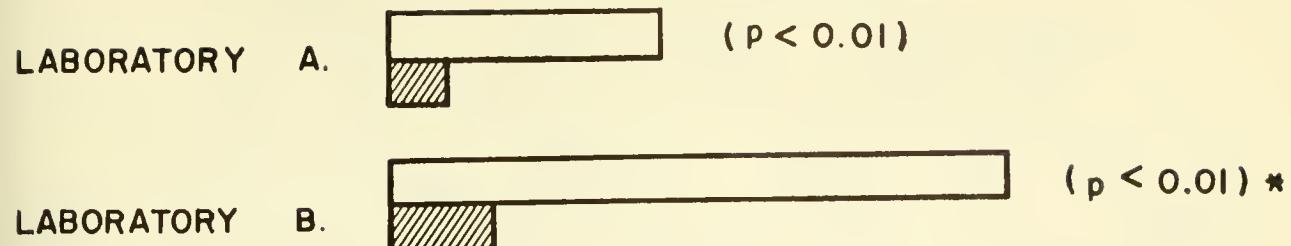
Insert Figure 2 here

between the selection of individuals for socialization and technical discussion in both laboratories. In Laboratory B this is due in part, but not entirely, to the rather tight clique found among the Ph.D.'s in the lab. As a matter of fact, among the Ph.D.'s alone, the amount of overlap is not significantly above chance. The networks for critical incident information and for new research ideas show a decidedly weaker relation to the socialization network in the laboratory (Figure 3)

Insert Figure 3 here

Only in the communication of new research ideas in Laboratory A, is the observed amount of overlap significantly above chance expectation. Nevertheless, since technical discussions among colleagues are certainly an important mechanism for transferring technical information of various sorts, and even though it is impossible from data such as these to determine the direction of the causal link (i.e., does socialization bring about transfer of technical information, or do people socialize more with those with whom they like to discuss technical matters), we are led to conclude that the informal structure of the lab occupies an important position in the transfer of information.

TECHNICAL DISCUSSION



CRITICAL INCIDENT INFORMATION

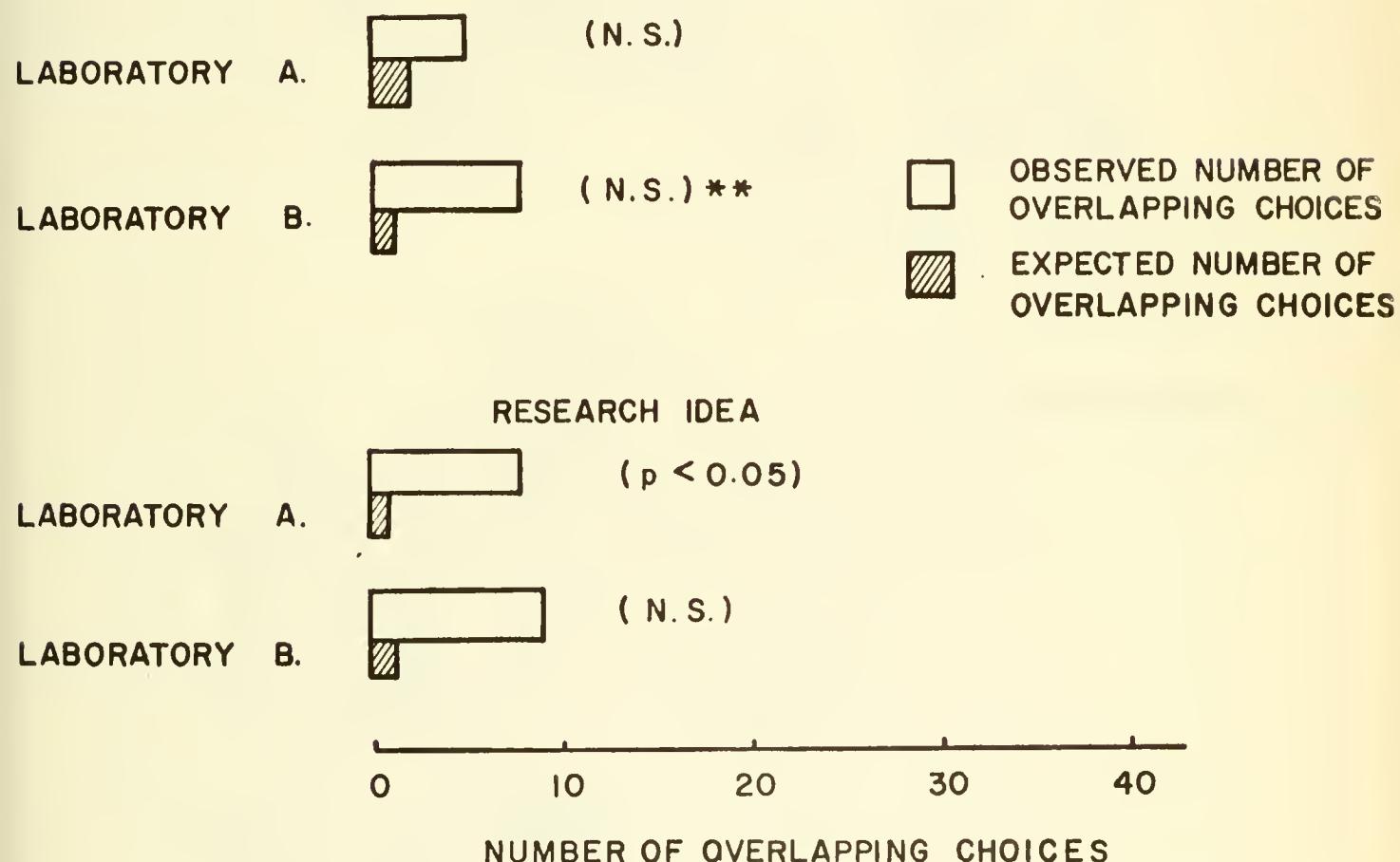
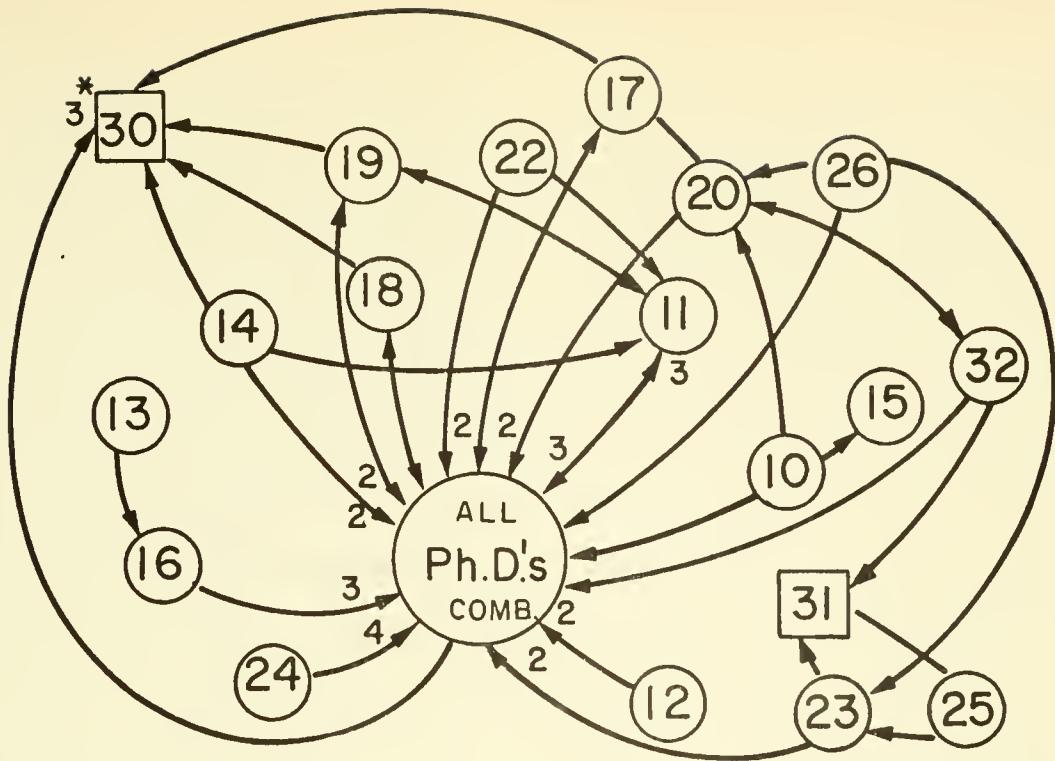


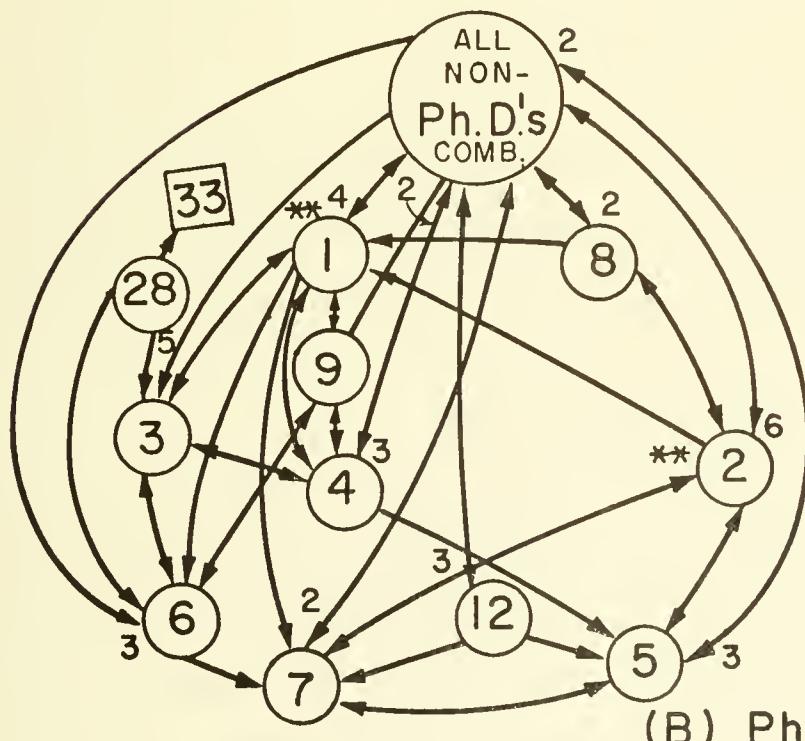
FIGURE 2. OVERLAP BETWEEN THE SOCIAL CONTACT NETWORK AND THREE TECHNICAL INFORMATION FLOW NETWORKS IN AN R&D LABORATORY

* DETERMINED BY KOLMOGOROV ON SAMPLE TEST

** N.S. = DIFFERENCE NOT STATISTICALLY SIGNIFICANT.



(A) NON Ph.D'S



□ = NON-RESPONDENT

(B) Ph.D'S

FIGURE 3. TECHNICAL DISCUSSION-CHOICES

- * WHERE MORE THAN ONE CONNECTION EXISTS, A HEAD INDICATES THE NUMBER OF CONNECTIONS.
- ** NUMBERS 1 AND 2 ARE THE RESEARCH DIRECTORS OF LABORATORY B.

A question now remains concerning the impact of the formal organizational structure upon communication. In Laboratory A, organizational relationships were taken directly from the departmental organization chart. People were considered to be members of common work groups when they reported to the same first line supervisor; the work group included each first line supervisor. In Laboratory B, no organization chart was available. Since the organization of that laboratory is quite flexible and revolves around a number of long- and short-term projects, all under one or two research directors, consideration of formal structure is restricted to the ad hoc project groups. The respondents in Laboratory B were asked to name "the people whom you consider to be members of your present work group." Figure 4 shows that while in both labs, much of the

Insert Figure 4 here

socialization occurs within work groups, the two networks are somewhat independent and should exert independent influences on information flow. If anything, the formal organization exerts an even stronger influence on communication (Figure 5)

Insert Figure 5 here

than does the informal socialization network. Work group structure influences not only technical discussion but new idea flow as well. This is not at all surprising, especially in Laboratory A, where the most frequently named recipient for new research ideas is the naming individual's immediate supervisor.

Controlling for the effects of the formal organization, by comparing only those social and technical discussion links which are external to each

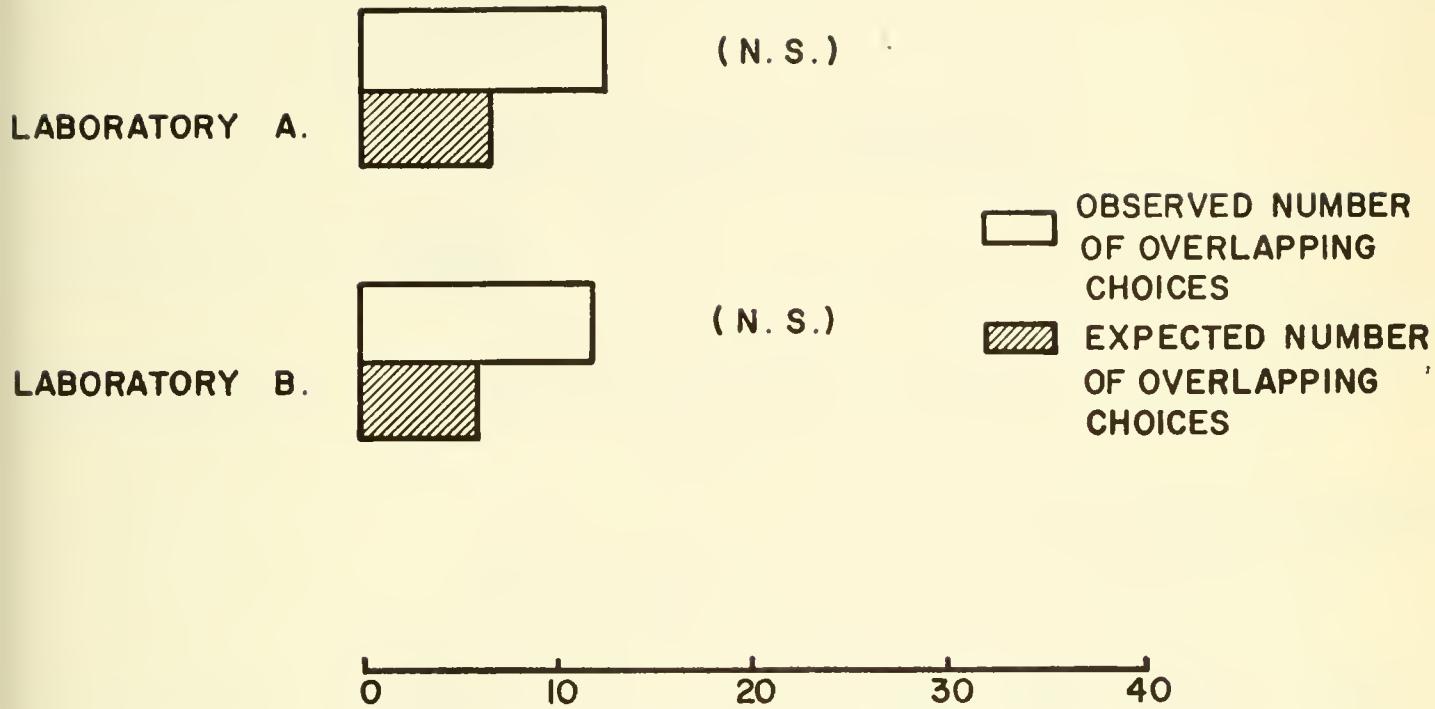
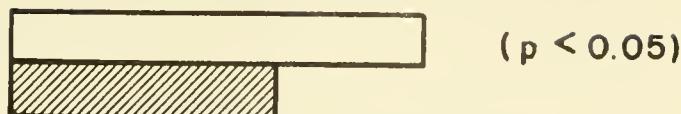


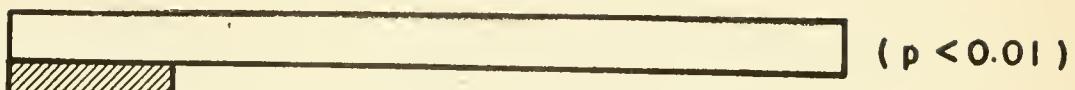
FIGURE 4. OVERLAP BETWEEN WORK GROUP STRUCTURE
AND THE SOCIALIZATION NETWORK IN TWO
R&D LABORATORIES

TECHNICAL DISCUSSION

LABORATORY A.



LABORATORY B.

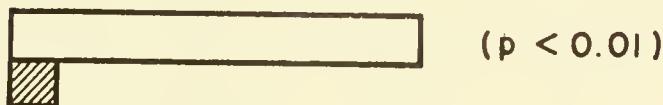


CRITICAL INCIDENT INFORMATION

LABORATORY A.



LABORATORY B.



RESEARCH IDEA

LABORATORY A.

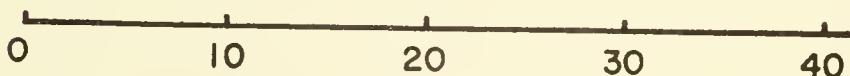


LABORATORY B.



OBSERVED NUMBER
OF OVERLAPPING
CHOICES

 EXPECTED NUMBER
OF OVERLAPPING
CHOICES



NUMBER OF OVERLAPPING CHOICES

FIGURE 5. OVERLAP BETWEEN WORK GROUP STRUCTURE AND THREE TECHNICAL INFORMATION FLOW NETWORKS IN TWO R&D LABORATORIES

individual's work group (Figure 6) produces a somewhat weaker relationship than

Insert Figure 6 here

that found when work group members were included. The formal organization is, then, the more important, but certainly not the sole determinant of information flow.

The Impact of Status on Communication

Several studies¹⁸ have shown that in the presence of prestige or status hierarchies, individuals of high status will tend to like and communicate frequently with one another, and individuals of low status will neither like nor communicate with one another as much. In addition, lower status members of the social system will direct most of their communication toward the higher status clique, without complete reciprocation.

The communications and social contact networks provide almost perfect examples in Laboratory B of this phenomenon. A casual glance at Figures 1 and 3 shows the impact of a status differential (in this case exemplified by possession of the doctorate) on the laboratory's communication network.¹⁹ The Ph.D.'s form a tightly knit clique and apparently communicate quite openly among themselves. But they seldom socialize or discuss technical matters with the

¹⁸J. Hurwitz, A. Zander and B. Hymovitch, Some effects of power on the relations among group members. In D. Cartwright and A. Zander (Eds.) Group Dynamics (2nd ed.; New York: Harper & Row, 1960).

T.M. Newcombe, The Acquaintance Process (New York: Holt, Rinehart and Winston, 1961).

¹⁹Since there were only two Ph.D.'s in Laboratory A, the phenomenon was not apparent there.

OBSERVED NUMBER
OF OVERLAPPING
CHOICES

EXPECTED NUMBER
OF OVERLAPPING
CHOICES

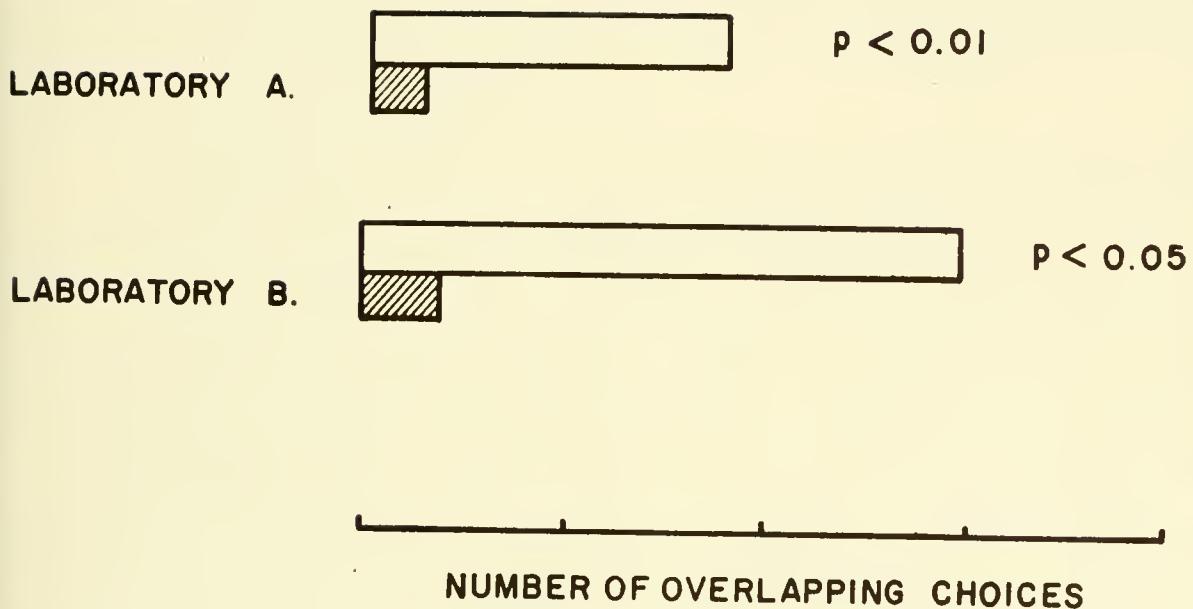


FIGURE 6. OVERLAP BETWEEN THE SOCIALIZATION AND
TECHNICAL DISCUSSION NETWORKS
EXCLUSIVE OF THE WORK GROUPS IN A
R&D LABORATORY

non-Ph.D.'s. This could, of course, be quite disruptive to organizational performance, but an even more serious effect is evident. The non-Ph.D.'s in the laboratory scarcely ever socialize with one another and discuss technical matters among themselves far less than do their Ph.D. colleagues.

Furthermore, the non-Ph.D.'s direct the majority of both their socialization (64%) and technical discussion choices (60%) to Ph.D.'s. The Ph.D.'s, in contrast, direct only 6% of their socialization and 24% of their technical discussion choices to non-Ph.D.'s.

The tendency on the part of the lower status members of a dichotomous hierarchy to direct their communications upward has been explained by Kelley²⁰ as a form of substitute upward locomotion. "Communication serves as a substitute for real upward locomotion in the case of low status persons who have little or no possibility of real locomotion." Kelley goes on to qualify this statement with the fact that it holds true only for those low status persons who exhibit some desire to move upward. Cohen²¹ has replicated these results with another experimental group and finds further that one form of upward communication (conjectures about the nature of the higher status job) increases both when "... locomotion is desired but not possible and where it is possible but not desirable."

The situation in Laboratory B can best be described as one in which upward mobility is highly desirable but, in the short run, impossible. It is therefore not surprising that the non-Ph.D.'s should attempt to enhance their own

²⁰H.H. Kelley, Communication in experimentally created hierarchies, Human Relations, 4, 1951, 39-56.

²¹A.R. Cohen, Upward communication in experimentally created hierarchies, Human Relations, 11, 1958, 41-53.

status through association with the higher status Ph.D.'s in the laboratory. In an organization in which both Ph.D.'s and non-Ph.D.'s work together in the same tasks, the most rewarding experiences, publication, recognition, etc., are almost bound to be restricted to those holding the advanced degree. This being the case, the non-Ph.D.'s are resigned to a strategy of gaining reflected glory as satellites of the higher status group. They therefore tend to veer away from association with their lower status colleagues and direct the majority of their attention toward the Ph.D.'s, thus attempting to gain through association the upward locomotion which is in reality denied to them.

Information Habits and Sociometric Communication Choices

Figure 3 shows quite clearly that some individuals are much more highly chosen than others for technical discussion. These highly chosen individuals, or sociometric "stars," may well be key links between the internal information network of the laboratory and the scientific and technological communities outside of the laboratory. To examine this possibility, the "stars" in two sociometrically-determined information networks²² will be compared with their colleagues to determine whether they display any systematic differences in their information gathering behavior. Specifically, it is hypothesized that the stars will make greater use of such sources as literature and friends outside of the organization; in other words, that they will act as "technological gate-keepers."

²²Stars being in the first case those people who are highly chosen for technical discussion, and in the second, those who were cited as sources of critical incident information. This analysis was performed in Laboratory B only, because although stars existed in Laboratory A, nothing is known of their information gathering behavior. An attempt to go back to this laboratory and obtain data on the information gathering behavior of stars and a matched sample of non-stars was abortive, as the result of poor co-operation.

In considering those members of the lab who are highly chosen for technical discussion²³ (Table IV), we find that the sociometric stars have more exposure to both the literature and to oral sources outside of the laboratory

Insert Table IV here

than does the average employee of the lab. This contrast is especially pronounced in the case of scientific and professional literature, that is journals published under sponsorship of scientific and engineering societies.^{24,25}

When requested to indicate the source of any information which influenced the course of their most recently completed research projects, twelve people cited seven other individuals within their own laboratory as the source of such information. In Table V these seven people are compared in terms of their own

Insert Table V here

²³Those who receive six or more technical discussion choices (eight respondents). This represents a split at one standard deviation above the mean number of technical discussion choices.

²⁴The identity of all technical periodicals to which each respondent subscribed to and/or read regularly was obtained, and those sponsored by engineering and scientific societies were separated out in the analysis.

²⁵Both research directors are included among the eight "stars." This was at first surprising since the question was directed at the discussion of purely technical matters and should have excluded administrative and organizational topics. Both of these men are apparently very competent technically, however. They are also included among the seven individuals who were cited as sources of critical incident information, and were between them responsible for all four of what the respondents almost unanimously agreed were the four best technical ideas that anyone in the laboratory had in the previous year. Eliminating the two research directors from the analysis in Table 4, does not significantly change the results (for personal friends outside the laboratory, $p = 0.11$; for the reading of professional and scientific periodicals, $p = 0.001$).

Table 4. Comparison of Communication Behavior and Technical Discussion Choices

Communication Characteristics	Number of Times Chosen on Technical Discussion Matrix		level of statistical significance
	six or more	four or fewer	
percentage who are above median in using personal friends outside the laboratory as an information source	64%	25%	0.06
percentage who are above median in using technical specialists within the laboratory as an information source	50	40	0.47
percentage who are above median in total number of technical periodicals read	88	40	0.01
percentage who are above median in number of professional and scientific periodicals read	75	35	0.001

* Based on Mann-Whitney U-Test performed between the two groups.

Table 5. Comparison of Communication Behavior and Identification as the Source of Special Technical Information During One of the Lab's Projects

Communication Characteristics	seven individuals cited	others	level of statistical significance
percentage who are above median in using personal friends outside the laboratory as an information source	67%	30%	0.10
percentage who are above median in using technical specialists within the laboratory as an information source	57	40	0.17
percentage who are above median in total number of technical periodicals read	100	45	0.05
percentage who are above median in number of professional and scientific periodicals read	86	35	0.03

*

Based on a Mann-Whitney U-Test performed between the two groups.

information gathering behavior in the same manner as were the technical discussion stars. We again see the pattern of greater contact with experts outside of the organization and more exposure to the literature.

Individuals who are highly chosen as sources of potential sources of technical information are considerably different from their colleagues. They have greater contact with technical people outside of the organization and are more exposed to the technical literature. Furthermore, they all rely to very much the same degree upon internal consultation.

There appear then to be two distinct classes of individuals within this laboratory. The majority have few information contacts beyond the bound of the organization. A small minority in contrast have rather extensive outside contacts and furthermore serve as sources of information for their colleagues. There is then evidence of a two-step flow of information in the laboratory studied. Six or seven individuals act as technological gatekeepers for the rest of the lab. As further support, it was found that two of these six or seven people were responsible for introducing all four of the "most important technical ideas" that had been introduced into the organization during the preceding year.

The gatekeepers themselves show some variation in the type of information sources they use. Some rely more upon the literature than upon oral sources, while some operate in reverse. A comparison of relative exposure to technically-oriented friends outside of the organization and to the scientific and professional literature shows a slight positive correlation ($Kendall\ Tau = 0.27$), but the relation does not approach statistical significance ($p = 0.21$). Quite fortunately, it would appear for the lab, the gatekeepers do not all tend the same gate.

CONCLUSIONS

The results of the current research provide substantial support for the two hypotheses concerning the gatekeeper and the role of primary groups. In the labs studied there definitely appear to exist technological gatekeepers, people to whom others turn for technical discussion and consultation, who in turn report having a greater amount of contact with the professional and scientific literature or with technically trained friends outside the laboratory. The gatekeepers mediate between the organization and its technological environment and provide a channel through which state-of-the-art technical information is brought into the organization. The flow of information into the R&D laboratory is then a two-step process. Information comes first to the gatekeepers who keep more abreast of the literature or cultivate more personal contacts outside of the laboratory. Then, since the gatekeepers occupy key nodes in the laboratory's communication network, this information can be easily disseminated through the organization.

The individual gatekeepers vary somewhat in the sources of information that they use. Some operate by translating from the literature; others from oral sources. Opinion leaders in the present context are not of a monolithic sort. They vary considerably in the nature of the sources from which they derive information and quite possibly in the functions for which their transmitted information is used. We are unable to test the latter possibility with the present data, but it remains an empirical question, and the subject for further research. This situation is not unlike that discovered in mass communication research. In that context, opinion leaders were found to be differentiated by topic; those who were influential in public affairs were not necessarily influential in determining fashion patterns, and so on. Moreover, the nature of the area of influence was found to be related to media exposure.

When medium content was taken into account, it was found (at a more detailed level of analysis) that movie leaders read movie magazines more, public affairs leaders read more news magazines, fashion leaders more fashion magazines, and so on, suggesting that we should look in more detail at the content of the messages processed by the various gatekeepers in R&D laboratories. We are implying that the selection of channels (e.g., literature vs. external oral sources) by scientific and technological gatekeepers may be based upon the qualitative nature of the information in which the gatekeeper specializes, and that channels vary in their ability to provide different types of information. For example, there is some evidence to suggest that the literature is most useful in providing information which is important for keeping abreast of the state of a technological field, while oral sources are probably better in providing more specific detailed information about particular techniques.²⁶ Gatekeepers who specialize in knowledge of the state-of-the-art would then tend to expose themselves more to the literature, while those specializing in particular research techniques would interact more with external oral source.

There does not appear, as yet, to be any clear-cut way to identifying gatekeepers on an a priori basis. One thing is quite clear concerning the gatekeeper, however. He is an important direct contributor to the efforts of the

²⁶ Menzel, Herbert. Scientific communication: Five themes from social science research. American Psychologist, 21, 1966, 999-1004.

Scott, Christopher. The use of technical literature by industrial technologists. Proceedings of the International Conference on Scientific Information, 1958.

Goodman, A.F., J.D. Hodges, Jr. and F.G. Allen. Final Report: DOD User Needs Study, Phase II: Flow of Scientific and Technical Information in the Defense Industry, North American Aviation, Inc., Autonetics Division, Anaheim, California, 1966.

laboratory. In both laboratories, the gatekeepers hold a significantly greater number of patents and have published a significantly greater number of papers than their colleagues. In Laboratory B they tended to occur more frequently among the Ph.D.'s. Only two members of Lab A had Ph.D.'s, and only one of them appears among the communication "stars" or gatekeepers category. An interesting thing in Lab A lies in the fact that two-thirds of the opinion leaders are first line supervisors. It may be recalled that the two research directors of Laboratory B are included among its eight opinion leaders. This observation brings up some rather interesting questions. Does an individual become a gatekeeper because he occupies a managerial position? Or does his promotion to management result, in part, from recognition of the value of his contribution to the organization as a gatekeeper? Certainly, holding a managerial position may provide an individual with easier access to people outside of his organization, but it is difficult to understand how it could possibly stimulate his technical reading habits! The direction of causality remains unclear. If, however, promotion to a supervisory position is a reward for gate-keeping activity, it is a self-defeating strategy. It places the man in a position from which his next promotion will most likely prevent him from effectively serving in the gate-keeping function. The second promotion will probably remove him too far from the actual technical work to allow him to maintain currency, and will impose a difficult organizational separation between himself and the average engineer in the organization. This can be seen in Laboratory A where the head of the department is two organizational levels above the bench engineers, and was not cited frequently enough to be considered an opinion leader.

There are two further managerial implications from this study which should not be neglected. First of all, the factors which influence the flow of technical

information in the organization must be understood. Some of these are under management's control and can be used to improve the functioning of the communication system. Second, the value of technological gatekeepers should be recognized. All too frequently organizational reward systems overlook the value of the information transfer function. Furthermore, research management often fails to make effective use of these individuals. A small amount of attention to these two points can produce great returns in terms of organizational effectiveness.

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